

## **Snow on Sea Ice Workshop - An Icy Meeting of the Minds: Modelers & Measurers**

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### **LONG-TERM GOALS**

The goal of the workshop was to promote more seamless and better integration between measurements and modeling of snow on sea ice, thereby improving our predictive capabilities for sea ice.

### **OBJECTIVES**

The key objective was to improve the ability of modelers and measurers work together closely. To that end, we felt that both groups needed to understand how snow process knowledge and properties distributions appear in the models, and what is and isn't possible when it comes to measuring snow on ice in the field. That cross-discipline understanding takes time to develop, so a secondary goal of the workshop was to establish the personal relationships between modelers and measurers that would underpin improved model development.

### **APPROACH**

We invited 14 researchers with a strong track record in either measuring or modeling snow on sea ice to come to Barrow, Alaska. There, over a three-day period, the group went out on the ice and made measurements of snow and ice cover, and spent time indoors talking about how large scale sea ice models are structured and constructed. Ample time for cross-discipline discussions was available.

### **WORK COMPLETED**

The workshop was held between April 28<sup>th</sup> (when the advance team arrived in Barrow) and May 1<sup>st</sup> (when the last participants left). The following 14 people attended (and had the travel covered by the grant): Modelers: Marika Holland, Elizabeth Hunke, Mark Flanner, Nicole Jeffery, Arnold Song, David Schroder, Olivier Lecomte, Andrew Roberts. Measurers: Don Perovich, Rob Massom, Melinda Webster, Oliver Dammann, Charlie Parr III, Alexandra Arnsten. Topics discussed included:

- Heat conduction: How do values of density, conductivity and emissivity vary?
- Snow-ice formation: Is it necessary (and even practical) to include wind-blown redistribution?
- Melt ponds: Is the way in which models collect melt water and rain into ponds sufficient?

- Distribution of snow as a function of ice roughness (level ice, ridges, ponds): Are these adequately represented in models?
- Snow heterogeneity: How can distribution functions be defined and then represented and used?
- Rain-on-snow: Is it becoming more prevalent? How does it affect the physical system, and what impact does it have on the ice and ice ecosystem?
- Snow crystal size: How does it evolve with temperature, moisture, aging, and wind?
- Snow optical properties: How are albedo and transmittance affected by snow depth, grain size, particulates, and water content?

This workshop was funded by the Office of Naval Research but NSF effectively co-sponsored it by providing support through their logistics provider in Barrow (UIC Science (<http://www.uicprofessionalservices.com/services/category/uic-science/arctic-science-logistics-support/>) as well as their other logistics provider (CPS, <http://cpspolar.com/services/field-workplanning-and-support/>), who covered lodging, conference room space, truck and snowmobile rental, and permitting assistance, radios, and bear guards. Half of the time was spent out on the ice making measurements; the other half inside discussing and working with models.

## RESULTS

A spatially heterogeneous and temporally changing snow cover resides atop Arctic and Antarctic sea ice for much of the year. This snow cover impacts the surface heat budget, the atmosphere–ocean heat exchange, ice growth, ice melt, and light transmission to the ocean. It must be accurately represented to properly treat the polar sea ice covers and related feedbacks in climate models, but that is a difficult proposition. To improve the modeling process we took a novel approach, bringing together researchers who primarily make field observations with ones who mainly utilize models of sea ice and climate. The workshop included both classroom and field components. The group discussed the properties of the snow cover on sea ice and how best to represent them in models. The workshop showed observers what snow properties are of greatest concern in climate models and gave modelers an opportunity to see and sample snow on sea ice. Classroom discussions highlighted how models often treat the snow cover as a single layer with uniform properties. This assumption was then confronted by on-ice measurements made by the workshop participants, who dug snowpits to measure vertical profiles of snow temperature, density, and grain size and shape and conducted surveys of snow depths. These measurements were made at two sites; rough first year ice and smooth first year ice. The observed stratigraphy indicated a two-layer snow cover comprised of a thick wind slab with a thin base layer of depth hoar. The wind slab consisted of rounded grains, which simplifies calculations of light reflection, absorption, and transmission in the snow. However, snow depth was far from uniform, with median values of 0.1 m for smooth ice and 0.3 m for rough ice; depths ranged from 0.02 to 1.20 m. The particulars of the observations, while interesting, are not the critical element. The key outcome was the collaborative interactions and discussions between modelers and observers. To focus future efforts, the group determined a few critical modeling concerns regarding snow on sea ice. These include the need for model parameterizations to represent factors driving the spatial heterogeneity of snow, and implementation of processes that drive snow metamorphism impacting snow thermal and radiative properties. During the workshop, observers learned what snow measurements are the most important from a modeling perspective. Modelers made in situ observations and experienced both the simplicity and complexity of snow on sea ice. This resulted in a better-informed and more coordinated

research community that will help to advance the development of improved snow-on-sea-ice treatments within climate models.

### **IMPACT/APPLICATIONS**

Our hope is that both measurers and models returned home more sensitized to what it takes to model snow on sea ice well, and made friends/colleagues with whom they can collaborate.

### **RELATED PROJECTS**

None

### **PUBLICATIONS**

Perovich, D. K., M. M. Holland, E. C. Hunke. Snow on Sea Ice: A Modeling Observing Workshop (Submitted to EOS).